SECTION 1. INTRODUCTION

INTRODUCTION

Currently, a great deal of attention is being focused on the possibility of using advanced technologies to develop an Automated Highway System (AHS) that allows hands-off/feet-off travel in one's own vehicle. Human factors issues related to potential implementations of an AHS have been explored in a two-stage program conducted for the Federal Highway Administration (FHWA). In the first stage of the program, seven experiments were conducted in the Iowa Driving Simulator. In the second stage, seven additional experiments have been conducted. This report presents the results of the sixth stage II experiment.

All of the stage I experiments and the first five experiments in stage II used an AHS configuration that would require little structural alteration to the roadways.[1] In contrast, in this experiment an AHS configuration was not used; instead, two intelligent vehicle systems were installed in the driver's car. The first of these, a *speed, steering, and gap control* system (SSGCS), was essentially a cruise-control system that had a selectable following-distance override and was able to steer within a lane; the second was a *collision warning* system (CWS) that was capable of detecting potential collisions and of providing a haptic alert to warn the driver. The experiment was conducted to determine how driving behavior was affected by driving with the aid of these two systems under different visibility and traffic-density conditions.

Fifty-two drivers participated in the experiment; each drove the simulator vehicle for a single trial that lasted 35 min. Thirty-two drivers were assigned to experimental groups: they had access to the intelligent vehicle systems while they were driving. The remaining 20 drivers were controls: the intelligent systems were not installed in the simulator vehicle when they drove.

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[1] This AHS configuration, which consisted of a three-lane expressway in which the left-most lane was reserved for automated traffic that traveled in strings of up to four vehicles, while the vehicles that remained under the control of their drivers traveled in the center and right lanes, was used to investigate the following:

- The transfer of control from the AHS to the driver as the simulator vehicle left the automated lane.(1)
- The transfer of control from the driver to the AHS as the simulator vehicle entered the automated lane.(2,3)
- The acceptability to a driver traveling under automated control of decreasing vehicle separations as a vehicle entered the automated lane ahead of the driver.(4)
- The effectiveness of the driver when he/she was required to control the steering and/or speed when traveling through a segment of the expressway in which the capability of the AHS was reduced.(5)
- The effect on normal driving behavior of traveling under automated control for very brief periods of time.(6)
- The behavior of the driver and the kind of information that he/she wanted to have available when his/her vehicle was traveling under automated control.(7)
- The effect on normal driving behavior of traveling under automated control for an extended period of time (a) when there were different distances between the driver's vehicle and the vehicle ahead and (b) with different methods of transferring control from the automated system to the driver.(8)

During the 35-min trial, driving-performance data were obtained from all 52 drivers while they experienced 1 of 2 traffic densities in 3 different visibility levels. At the start of the trial, the driver's car was positioned on the entry ramp of an expressway. The driver's task was to enter the expressway and drive for the duration of the trial. The drivers in the experimental group were encouraged to use each of the intelligent systems once, but received no further instructions during the drive. The behavior of the drivers was videotaped.

The experiment was conducted with two traffic densities and three visibility conditions. The density was varied between drivers. For half of the drivers (16 from the experimental group and 10 from the control group), the traffic density was 6.41 v/km/ln (10 v/mi/ln), while for the remaining half (also 16 experimentals and 10 controls), the density was 12.42 v/km/ln (20 v/mi/ln). Visibility was a within-subjects variable. The trial was divided into three sections, each of which lasted approximately 11 min. In the first section of the trial, the visibility was clear (10 km [6.21 mi]). At the end of the first section of the drive, radiation fog[2] began to form, reducing the visibility. By the start of the second section, the visibility had dropped to 200 m (656 ft). At the end of the second section of the trial, the fog thickened and the visibility deteriorated again. The driver finished the trial by driving the third section in 100-m (328-ft) fog. The transitions from one level of visibility to the next occurred gradually and naturally. All 52 drivers experienced the three different visibility conditions in the same order. In a previous study, Harms used the Swedish Driving Simulator to investigate the effect of fog on driving behavior.(9) She examined the effect of reduced visibility on the driver's speed and steering performance, and found that the driver's mean speed decreased as the visibility level decreased, but that lateral position and lateral variation were not affected.(9) One of the questions in the current study was whether a similar result would be obtained when the driver was able to use a SSGCS and CWS.

Both objective driving-performance data and subjective driver-preference data were collected during the experimental sessions. Then, the data obtained from the drivers in the experimental and control groups were analyzed and compared in order to determine whether the driving behavior of the drivers who were able to use the intelligent vehicle systems was different from that of those who did not have access to the systems.

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[2]Radiation fog is ground surface-based fog that occurs when ambient air cools to saturation.

OBJECTIVES

The objectives of this experiment were:

- To determine whether driving behavior is affected when the driver has access to a SSGCS and to a CWS.
- To determine whether driving performance is affected by reductions in visibility.
- To determine whether driving performance is affected by variations in traffic density.

To achieve these objectives, driving-performance data were obtained from 52 drivers: 32 drove with both the SSGCS and CWS and 20 were controls. The analyses of these data focused on the following experimental questions:

- *Does driving performance change with the use of the intelligent vehicle systems?*
- *Is driving performance affected by the age of the driver?*
- *Does driving performance change when the visibility level is reduced?*
- *Does driving performance vary with traffic density?*